

## METHOD FOR FABRICATING A THIN FILM RESISTOR

### CROSS-REFERENCE TO RELATED APPLICATION

5           This application claims the priority benefit of Taiwan application serial no. 89116610, filed Aug. 17, 2000.

### BACKGROUND OF THE INVENTION

#### Field of the Invention

10           The present invention generally relates to a method for fabricating a semiconductor device, and more particularly to a method for fabricating a thin film resistor.

#### Description of the Related Art

15           Resistors are devices used in mixed-mode integrated circuits. In terms of rectangular block resistors, resistance value (R) is in direct proportion to the length (L) of the rectangular block and is in inverse proportion to the cross-sectional area (A) of the rectangular block. Thus, resistance is calculated as  $R = \rho (L/A)$  where  $\rho$  is the resistivity of the material, L is the length of the resistor along the direction of the current and A is the cross sectional area of the resistor along the direction of the current.

20           In conventional practice, heavy dopants are applied to a portion designated as the bottom electrode of the transistor's capacitor and light dopants to a portion designated as the resistor on the same polysilicon layer. The top electrode of the capacitor and the gate electrode are formed on another polysilicon layers.

Lightly doped polysilicon thin film resistors are generally formed in the shape of a

rectangle. Changing the doping concentration of the polysilicon layer allows the fabrication of resistors with different levels of resistivity. With the increased integration of semiconductor devices, requirements on the properties of materials used in semiconductor fabrication have also risen enabling devices to be formed in smaller dimensions with greater performance.

Polysilicon is the material used in the conventional method of fabricating thin film resistors. However, during the post-ion implantation annealing of high resistive polysilicon thin film resistors, doped material diffuses out increasing resistivity and lowering current flow, which makes it difficult to control the quality of the product. Additionally, the surface of the polysilicon layer may be oxidized during the subsequent thermal oxidation step reducing the effective dimension of the polysilicon layer. Moreover, the implanted dopants may also be consumed during the thermal oxidation causing imprecise resistivity of the thin film resistor.

Figs. 1A-1D show the fabrication steps of a conventional high resistive, polysilicon thin film resistor and gate electrode. As shown in Fig. 1A, a shallow trench isolation region 102 is formed on a substrate 100 provided to isolate an active area 104. A polysilicon layer is deposited over the substrate using the chemical vapor deposition.

As shown in 1B, dopants 110, in the form of ions, are implanted into the polysilicon layer 106 to lower its resistivity.

As shown in 1C, after ion implantation 108 has been completed, the substrate is annealed in a chamber containing inert gas to restore the lattice structure and electrical type of the surface of the lightly doped polysilicon layer 106a causing the dopants implanted in the lightly doped polysilicon layer 106a to undergo thermal diffusion. Moreover, some of the dopants 110 will diffuse out increasing the resistivity of the

lightly doped polysilicon layer.

As shown in Fig. 1D, the lightly doped polysilicon layer 106a is patterned to form a high resistive thin film resistor structure 106b above the shallow trench isolation region 102. This high resistive thin film resistor structure is an important part of the conventional, high resistive thin film resistor.

As shown in Fig. 1E, a thermal oxidation process is performed to form a gate oxide layer 112 on the substrate 100. The silicon oxide 116 is formed on the surface layer of the high resistive thin film resistor structure during the thermal oxidation reducing the effective dimension of the high resistive thin film resistor 106b. Moreover, implanted dopants 110 are consumed. A patterned, doped polysilicon layer 114 is formed above the gate oxide layer 112. This patterned, doped polysilicon layer 114 serves as the gate layer for a metal oxide semiconductor transistor.

During the post-ion implantation annealing step described in the conventional practice above, dopants implanted in the polysilicon layer undergo a thermal diffusion. Consequently, some of the dopants diffuse out. Additionally, during the thermal oxidation step of the conventional practice described above, the surface of the lightly doped polysilicon layer oxidizes and becomes silicon oxide. As a result, the effective dimensions of the lightly doped polysilicon layer are changed. Moreover, during the process of thermal oxidation implanted dopants are consumed.

Thus, during the fabrication process of high resistive, polysilicon thin film resistors and gate electrodes, resistivity undergoes considerable change causing ineffective resistance.

## SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a method for fabricating a high-resistive thin film resistor that prevents implanted dopants from diffusing out or being consumed during subsequent stages in the fabrication process.

- 5        It is another object of the present invention to provide a method for fabricating a high-resistive thin film resistor that prevents oxidation on the surface of the polysilicon layer during the subsequent step of thermal oxidation. Thus, the effective dimensions of the polysilicon thin film resistor can be maintained.

- 10       In accordance with the foregoing and other objectives of the present invention, a method for fabricating a high-sensitive thin film resistor is provided, in which an isolation region is first formed on a substrate to isolate an active device. A polysilicon layer is formed above the substrate. A diffusion barrier layer is formed above the polysilicon layer. Lightly doped ions are implanted into the polysilicon layer. A post-ion implantation, high-temperature annealing process is performed on the substrate.
- 15       The diffusion barrier layer and lightly doped polysilicon layer are patterned to form a high resistive, thin film resistor. Spacers are formed on the sidewalls of the thin film resistor.

- 20       In accordance with the method of the present invention for fabricating a thin film resistor, a diffusion barrier layer is formed above the thin film resistor. Moreover, spacers are formed on the sidewalls of the thin film resistor to raise resistivity.

It is to be understood that both the foregoing general description and the following detailed description are exemplary, and are intended to provide further explanation of the invention as claimed.

## BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings are included to provide a further understanding of the invention, and are incorporated in and constitute a part of this specification. The drawings illustrate embodiments of the invention, and, together with the description,  
5 serve to explain the principles of the invention. In the drawings,

Figs. 1A-1E are cross sectional views showing the processing steps for fabricating a conventional thin film resistor and gate electrode; and

Figs. 2A-2G are cross sectional views showing the processing steps for fabricating a thin film resistor according to one preferred embodiment of this invention.

10

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

Reference will now be made in detail to the present preferred embodiments of the invention, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers are used in the drawings and the description to  
15 refer to the same or like parts.

Reference is now made to Fig. 2A where an isolation region 202 and an active region 204 are formed on a substrate 200 provided. The isolation region 202 separates the active regions. The isolation region can be, for example, a shallow trench isolation region. A polysilicon layer 206 is formed above the substrate 200. The method for  
20 forming polysilicon layer 206 can be, for example, the low pressure chemical vapor deposition method, and the thickness of the polysilicon layer 206 is preferably of about 2000 Angstroms.

As shown in Fig. 2B, a diffusion barrier layer 208 is formed above the polysilicon layer 206. The material used to form the diffused layer can be an amorphous material

with greater density such as silicon dioxide. The method for forming diffusion barrier layer 208 can be, for example, the low chemical vapor deposition method in which the deposited material has a preferable thickness of between 100 and 500 Angstroms. The amorphous silicon or silicon dioxide material is much denser which can prevent dopants from diffusing out of the polysilicon layer during the subsequent post-ion implantation process.

As shown in Fig. 2C, lightly doped ions are implanted into the polysilicon layer 206 to lower its resistivity. Dopants 210 can be for example boron, phosphorus or arsenic.

As shown in Fig. 2D, after the ion implantation step 212 is completed, the substrate 200 is annealed in a chamber containing inert gas which causes the thermal diffusion of implanted dopants 210 within the lightly doped polysilicon layer 206a. Because the diffusion barrier layer 208 is formed above the lightly doped polysilicon layer 206a, the diffusion of dopants can be prevented, which assures that dopants 210 are evenly diffused within the lightly doped polysilicon layer 206a.

As shown in 2E, the lightly doped polysilicon layer 206a and diffusion layer 208 are patterned to form a high resistive thin film resistor structure 214 above the isolation region 202. The high resistive thin film resistor structure 214 is a primary part of the thin film resistor. Moreover, the thin film resistor structure 214 is formed through the patterning of the lightly doped polysilicon layer 206b as well as the diffusion barrier layer 208b.

As shown in 2F, a conformal insulation layer is deposited over the substrate 200 (not shown in the figure). The insulation layer is etched back to form spacers 216 on the sidewalls of the high-resistive, thin film resistor structure 214. The material for the

insulation layer can be silicon dioxide for example.

As shown in Fig. 2G, a gate electrode oxide layer 218 is formed above substrate 200. The method for forming the gate electrode oxide layer 218 can be for example the thermal oxidation. The gate electrode oxide layer 218 has a preferable thickness of  
5 between 100 and 250 Angstroms. A patterned, doped polysilicon layer 220 is formed above the gate electrode oxide layer 218. This patterned, doped polysilicon layer 220 serves as the gate electrode for a metal oxide semiconductor transistor. The method of forming the patterned, doped polysilicon layer can be the low-pressure chemical vapor deposition method, for example. The preferable thickness of the deposited material is  
10 about 2000 Angstrom.

Based on the foregoing, according to one preferred embodiment of the present invention, the high-resistive thin film resistor structures have the diffusion barriers which prevent dopants from diffusing out or being consumed during subsequent stages in the fabrication process.

15 Additionally, the present invention prevents oxidation on the surface of the polysilicon layer during the subsequent step of thermal oxidation. Thus, the effective dimensions of the polysilicon thin film resistor can be maintained.

The method of fabricating the thin film resistors according to one preferred embodiment of the present invention can be used to raise the degree of uniformity,  
20 stability and accuracy of the polysilicon thin film resistors while also maintaining the reliability of the device.

It will be apparent to those skilled in the art that various modifications and variations can be made to the structure of the present invention without departing from the scope or spirit of the invention. In view of the foregoing, it is intended that the

present invention cover modifications and variations of this invention provided they fall within the scope of the following claims and their equivalents.